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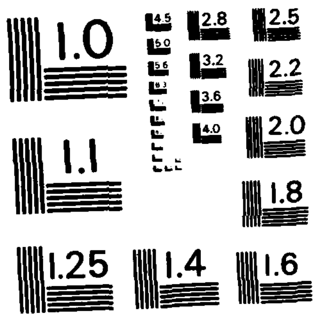

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MELBOURNE, VICTORIA

REPORT

MRL-R-872

DEGAS

A SUBROUTINE TO ISOLATE MATERIAL PACKAGES

IN THE HELP HYDRODYNAMIC CODE

David L. Smith

Approved for Public Release

FEBRUARY, 1983

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The Eulerian hydrodynamic code HELP is being used at MRL to model the behaviour of warheads. One of the most frequent problems experienced with the code is a breakdown of the pressure iteration in mixed cells where two materials have very disparate densities and/or masses: this occurs often when explosive-metal interactions are modelled. This report describes an addition to the code which allows the removal of gases or other materials once their effects become insignificant.

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SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED

DOCUMENT CONTROL DATA SHEET

REPORT NO.	AR NO.	REPORT SECURITY CLASSIFICATION
MRL-R-872	AR-003-281	UNCLASSIFIED

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REPORT DATE	TASK NO.	SPONSOR
February, 1983	DST 82/192	DSTO

CLASSIFICATION/LIMITATION REVIEW DATE	CLASSIFICATION/RELEASE AUTHORITY
	Superintendent, MRL Physical Chemistry Division

SECONDARY DISTRIBUTION

Approved for Public Release

ANNOUNCEMENT

Announcement of this report is unlimited

KEYWORDS

Shaped charges	HELP Hydrodynamic code
Computer programs	DEGAS
	Collapsing liner warheads
	Explosive-metal interactions

COSATI GROUPS 0902 1904

ABSTRACT

The Eulerian hydrodynamic code HELP is being used at MRL to model the behaviour of warheads. One of the most frequent problems experienced with the code is a breakdown of the pressure iteration in mixed cells where two materials have very disparate densities and/or masses: this occurs often when explosive-metal interactions are modelled. This report describes an addition to the code which allows the removal of gases or other materials once their effects become insignificant.

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DEGAS

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IN THE HELP HYDRODYNAMIC CODE

1. BACKGROUND

1.1 Use of the HELP code at MRL

Sophisticated computer codes which model material behaviour are being used increasingly as an adjunct to experimental investigations. Their purpose is to guide the experimenter in his choice of experiments and to help him to understand the physics underlying his experiments. Frequently such computer codes can be used to reduce drastically the number of difficult or expensive experiments required by a research programme.

At MRL computer codes are being used to model the behaviour of explosives and explosively driven devices. Computer modelling is particularly appropriate to explosives research, as direct measurement of explosive phenomena requires sophisticated instrumentation and expensive facilities.

The Warheads Research Group at MRL is using the US CODE "HELP" (Hydrodynamic ELastic Plastic) to assist in its experimental research on metal-lined warheads. HELP is a two-dimensional Eulerian hydrodynamic code, originally develoiped for hypervelocity penetration studies. A detailed description of the code may be found in Reference [1]. The version in use at MRL [2] was obtained from the US Army Ballistic Research Laboratory through the auspices of TTCP. BRLHELP contains explosive burn routines and other facilities to allow the study of explosive phenomena. This, combined with the Eulerian geometry which allows large material distortions to be followed by the code, made BRLHELP an attractive choice for the study of collapsing liner warheads.

HELP is being run on the CSIRONET CDC 7600 computer, through the CSIRONODE installed at MRL. Currently the code is being used in support of an experimental investigation of wide-angled shaped charges for the attack of light armour. One of the aims of the experimental programme is to optimise parameters such as the thickness, curvature, and cone angle of the shaped charge liner to produce coherent projectiles of the desired shape and velocity. The use of HELP minimises the number of firings required to obtain such data. Figure 1 shows a schematic illustration of one such device, and Figure 2 shows an experimental flash radiograph of the ensuing projectile at 200 microseconds.

1.2 Common Difficulties Encountered in Running the Help Code

Obtaining the best performance from a sophisticated computer code such as HELP is as much art as science. Only experience can tell the user what values of input parameters will result in the most stable calculations for a given problem type. However some difficulties with HELP are more intrinsic, and can be anticipated with most problems.

One of the most frequent causes of instability in the HELP code is the pressure iteration. The pressure in a single-material cell is computed directly from the material density and internal energy using the equation of state. The Eulerian logic of the code, however, allows multi-material (mixed) cells, and the pressures in these cells are derived by iteration. The densities of the component materials of a mixed cell are varied, subject to filling the cell exactly, until the component pressures converge to a common value, taken as the cell pressure. This iteration can lead to unrealistic answers when materials in a mixed cell have very disparate densities and/or masses.

When the pressure iteration fails under these conditions (even though convergence is obtained) a "rogue" cell is created where, usually, a small amount of material has physically unlikely properties. Unfortunately although one such rogue cell may be of little concern to the user, it is likely to affect the overall functioning of the code, for example via the time-step calculation. The normal procedure in such a case is surgery. The code senses trouble and stops, relevant quantities in the rogue cell are adjusted by the user, and the code is restarted from the binary dump file. This type of procedure is common for adjusting minor hiccups in the running of large hydrodynamic codes.

Experience with the use of HELP to model explosive-metal interactions has shown that the above problems occur quite frequently when a mixed cell contains low density gaseous detonation products as well as condensed material. Late in a calculation, both the pressures and densities of these gases are decreasing with time, exacerbating the problem. Here the approach of fixing a rogue cell and continuing is inappropriate, as the condition will recur. A better approach, assuming the gases are no longer making physically significant contributions to the problem, is to remove them altogether. (For most explosives problems 1 kPa would be a reasonable pressure threshold.) This approach has the additional benefit of increasing the run-time economy of the code.

2. DEGAS - DESCRIPTION AND USE

The purpose of the subroutine "DEGAS" is to remove explosives gases from the grid of a HELP calculation. The logic of HELP is such that it is not particularly easy to "fool" the code into believing that material has disappeared (for example by zeroing its equation of state). The main reasons for this are the interface cells, which have their own quite complicated logic, and the massless tracer particles, which are sensed by the code as material boundaries.

For simplicity, DEGAS does not remove only gases, but rather isolates material package one, removing all other materials and associated array quantities from the calculational grid. This will almost always satisfy those using the code for warhead studies, where the projectile is of prime interest, and other materials such as the expanded explosive, as well as any casings, wave-shaping inerts etc, may be discarded once their influence on the projectile has ceased. DEGAS can however be modified by the knowledgeable user to remove selective material packages as required.

Appendix 1 contains an UPDATE run [3] to add DEGAS to the HELP code, including a Fortran listing. It also includes a minor correction to the code, IDENT MOVERR, which prevents the tracers at the end-points of material packages from being stranded. (The use of DEGAS made this error more likely to manifest itself.)

3. EXAMPLES OF THE USE OF DEGAS

Reference [2] details a sample problem for use with HELP, involving a hemispherical shaped charge, 1.5 inch diameter. This sample problem was used during the installation of HELP at MRL, and Figure 3 shows outlines of the copper liner towards the end of one such run. This run terminated after approximately 17.5 microseconds, due to problems associated with the pressure iteration in a mixed cell. BRL appear to have had similar experiences as the output in [2] stops at 18 microseconds. When the same problem was restarted using DEGAS, as would be expected the code ran for much longer. Figure 4 gives output for up to 24 microseconds, and shows that stretching of the liner has increased significantly. (In fact the problem ran to over 60 microseconds, but results after 24 microseconds were of little value as (i) the liner had virtually stopped stretching and (ii) the tracers started to generate physically silly results near the base of the liner.)

Figure 5 shows tracer outlines from a HELP run on the problem shown in Figure 1. Again this run stopped because of problems in a mixed cell containing metal and expanded HE, and again this occurred before the metal liner had reached a stable shape. With the geometry used (4 inch diameter charge) both experiment and theory predicted that the liner would stabilise somewhere between 150 and 200 microseconds. Figure 6 shows some of the output from a restart of this problem using DEGAS. The liner reaches a stable shape at about 160 microseconds.

The "tails" on the metal liner derive from failed material, and are no longer behaving in a physically realistic manner. The manual removal of this material from the code is quite complex, so a subroutine CLIP has been written to do this. CLIP is quite similar to DEGAS in that most of the subroutine is taken up with "housekeeping" so that the code's accounting systems are satisfied. Appendix 2 contains an UPDATE run [3] to add CLIP to the HELP code, and includes a Fortran listing.

Figure 7 shows some output from a restart of the above problem, using DEGAS and CLIP. Cropping the metal liner in this case produces output that is more readily understood: it also decreases the code's runtime and prevents tracers from crossing each other. To some extent it will also lead to more reliable calculations, as rogue cells from failed (and physically unrealistic) portions of the material are prevented from controlling the timestep.

4. ACKNOWLEDGEMENTS

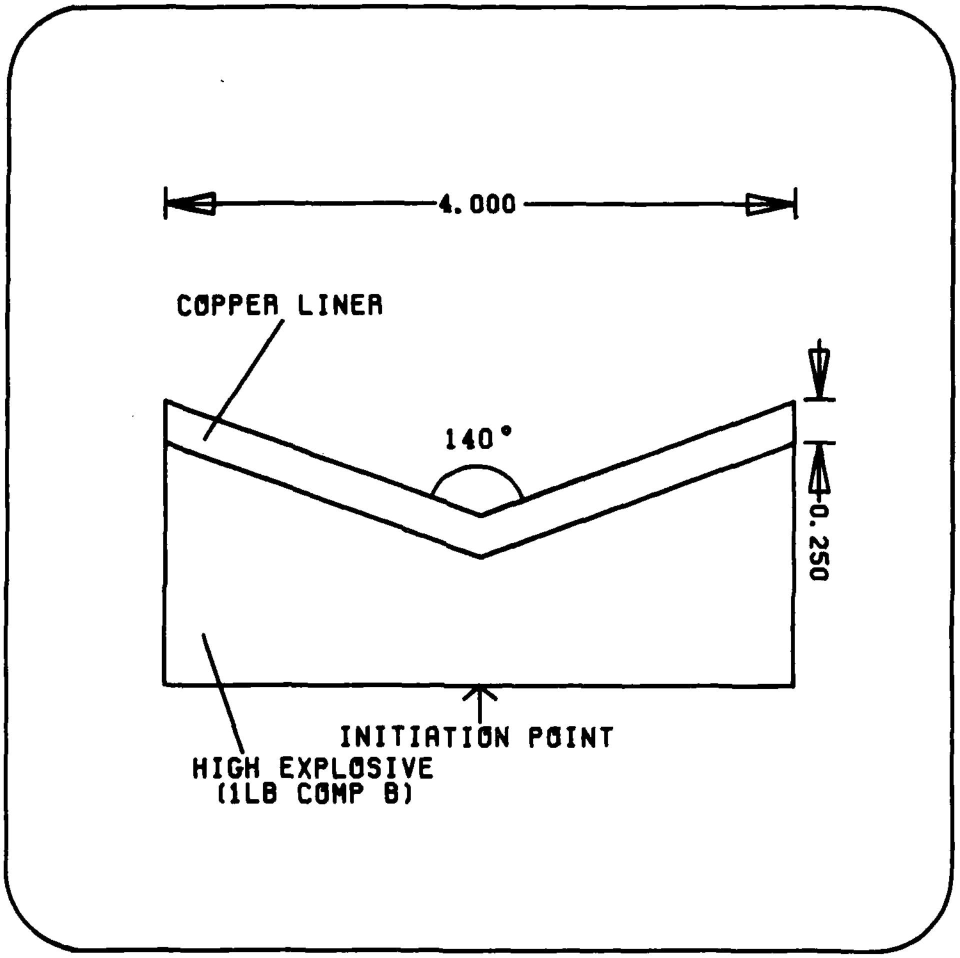
The author would like to acknowledge gratefully the value of discussions with Dr Mark Wilkins of Lawrence Livermore National Laboratory, California, during his recent visit to Australia. Thanks are also due to Miss K.A. Dunstall and Mr M.R. Fitzgerald for processing code output into graphical form.

5. REFERENCES

1. HELP - A Multimaterial Eulerian Program in Two Space Dimensions and Time.
   L.J. Hageman et al, Systems, Science and Software
   Final Report AFATL-TR-76-45, April 1976.

2. The BRL 7600 Version of the HELP Code.
   J. Lacetera et al, US Army Ballistic Research Laboratory
   Technical Report ARBRL-TR-02209, January 1980.

3. UPDATE Reference Manual.
   Control Data Corporation, Manual 60449900
   (UPDATE is a utility for maintaining large files.)



All dimensions in inches

FIGURE 1. Schematic of Wide-angled Shaped Charge.

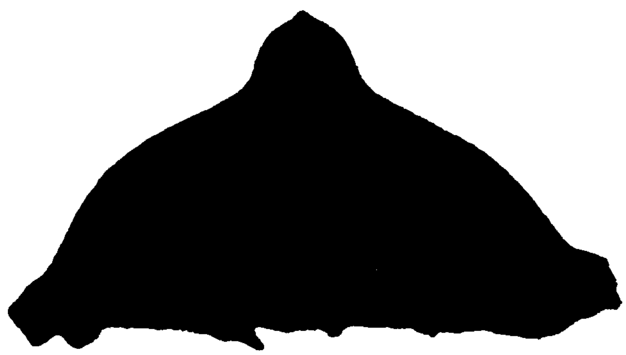


FIGURE 2. Flash Radiograph from Wide-angled Shaped Charge.

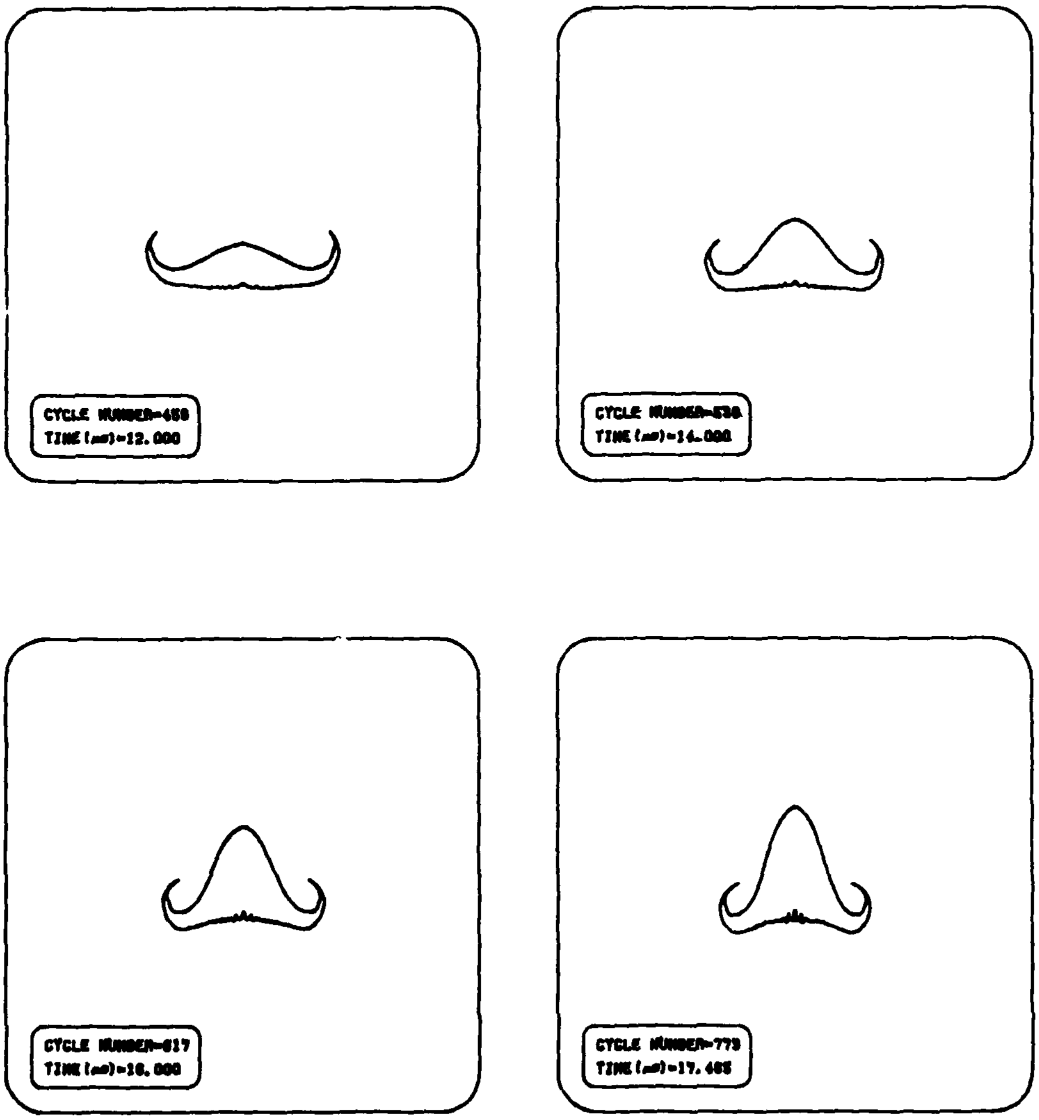


FIGURE 3. Hemispherical copper liner run.

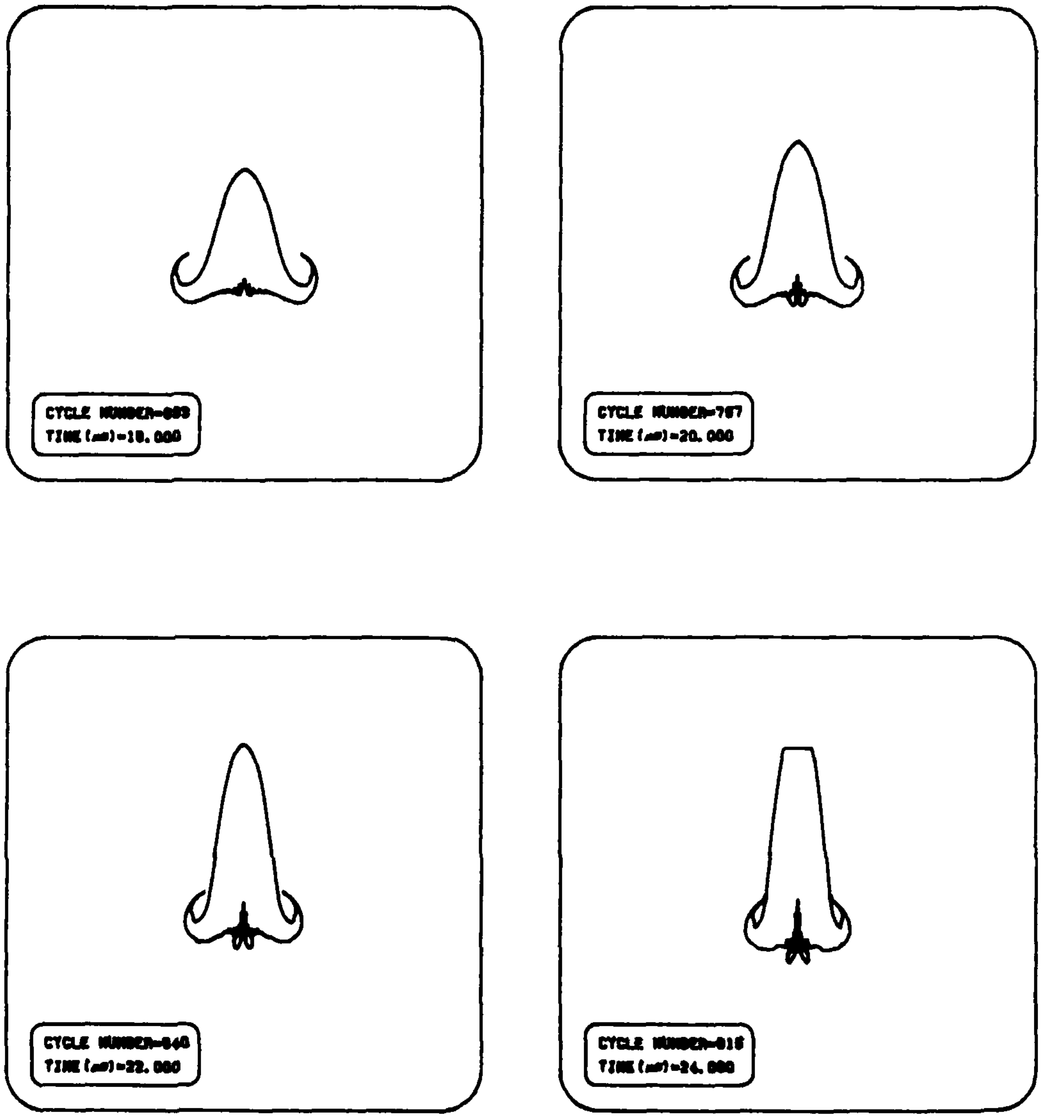


FIGURE 4. Hemispherical Copper Liner Restart with DEGAS.

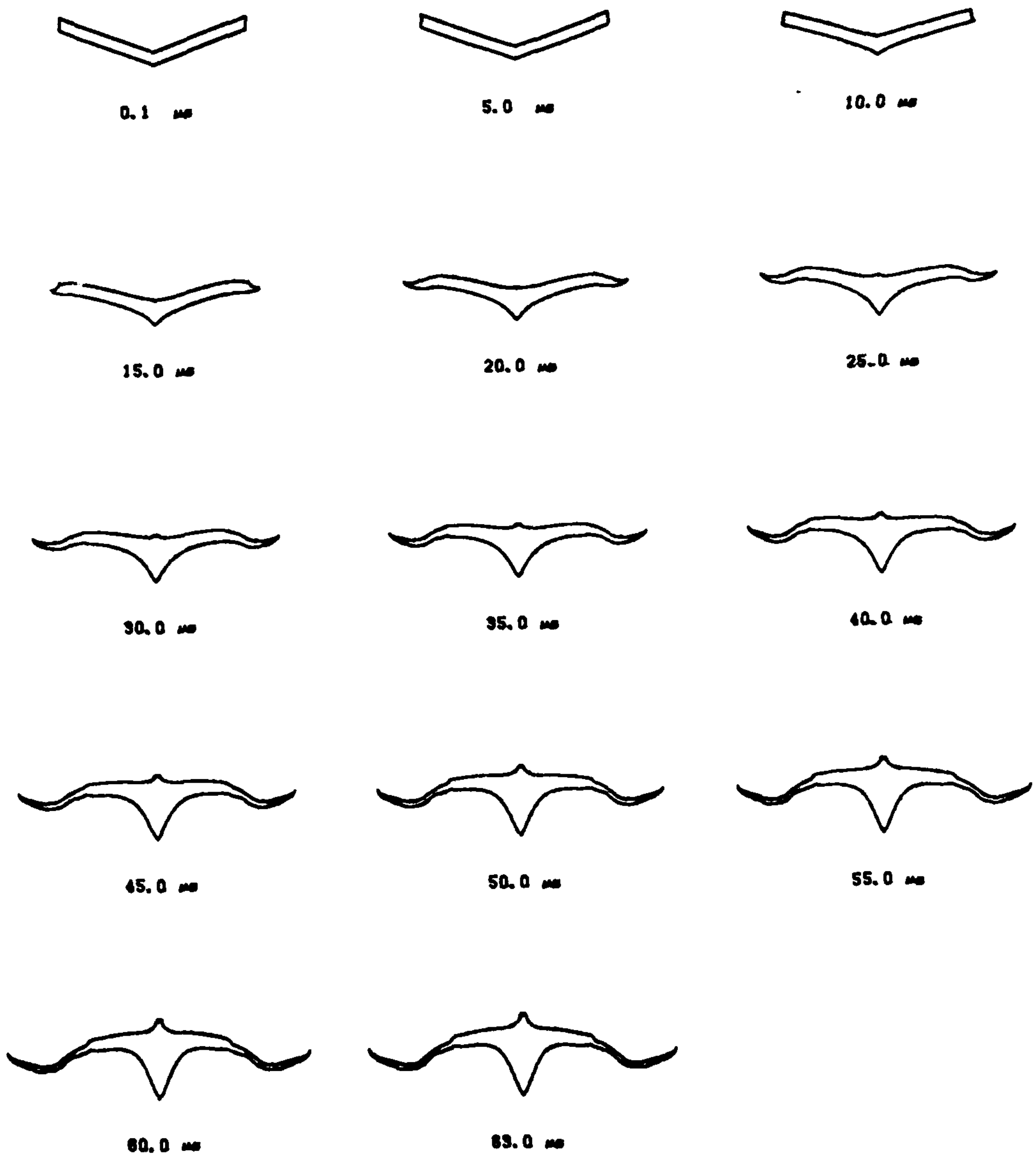


FIGURE 5. Wide-angled Shaped Charge Run.

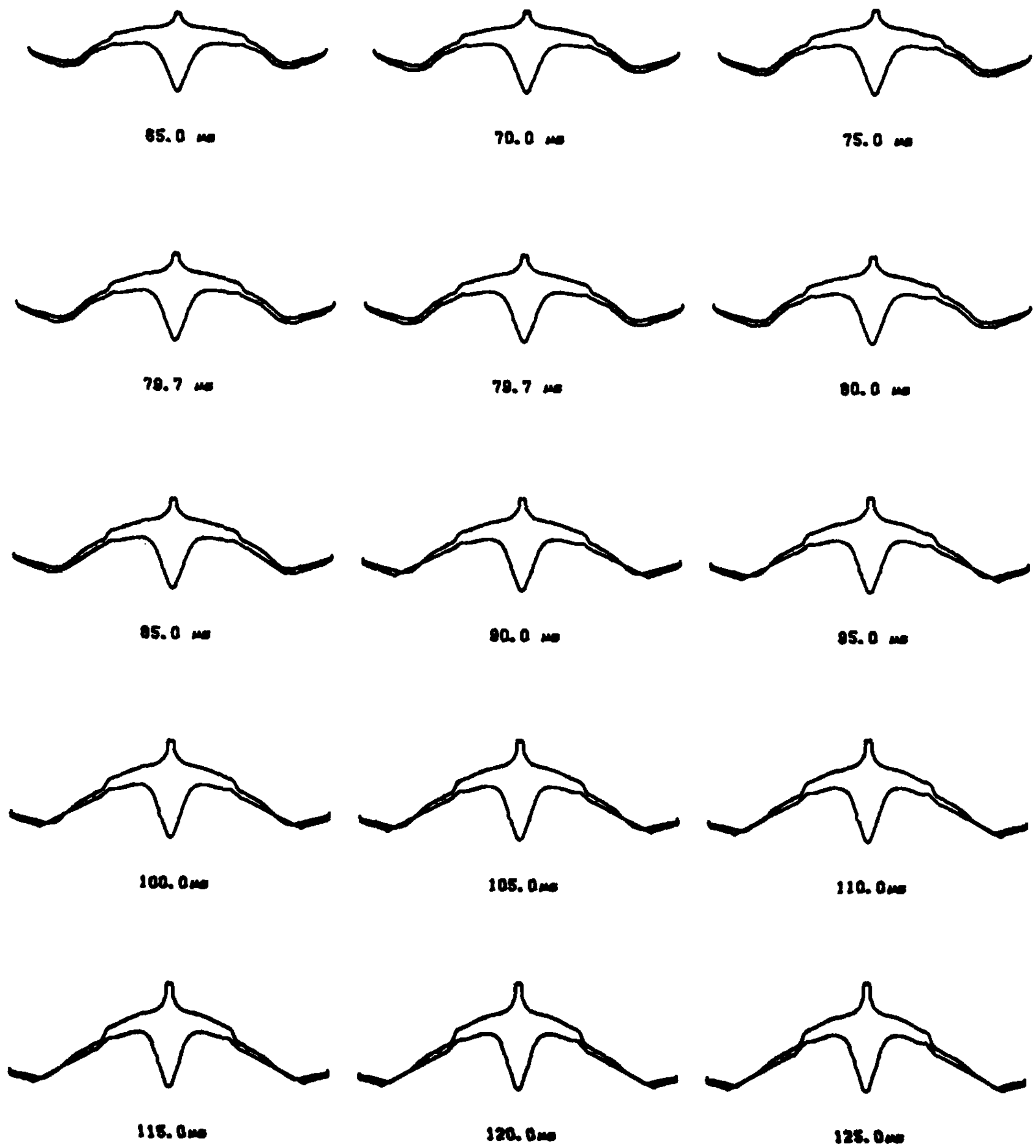


FIGURE 6. Wide-angled Shaped Charge Restart with DEGAS.

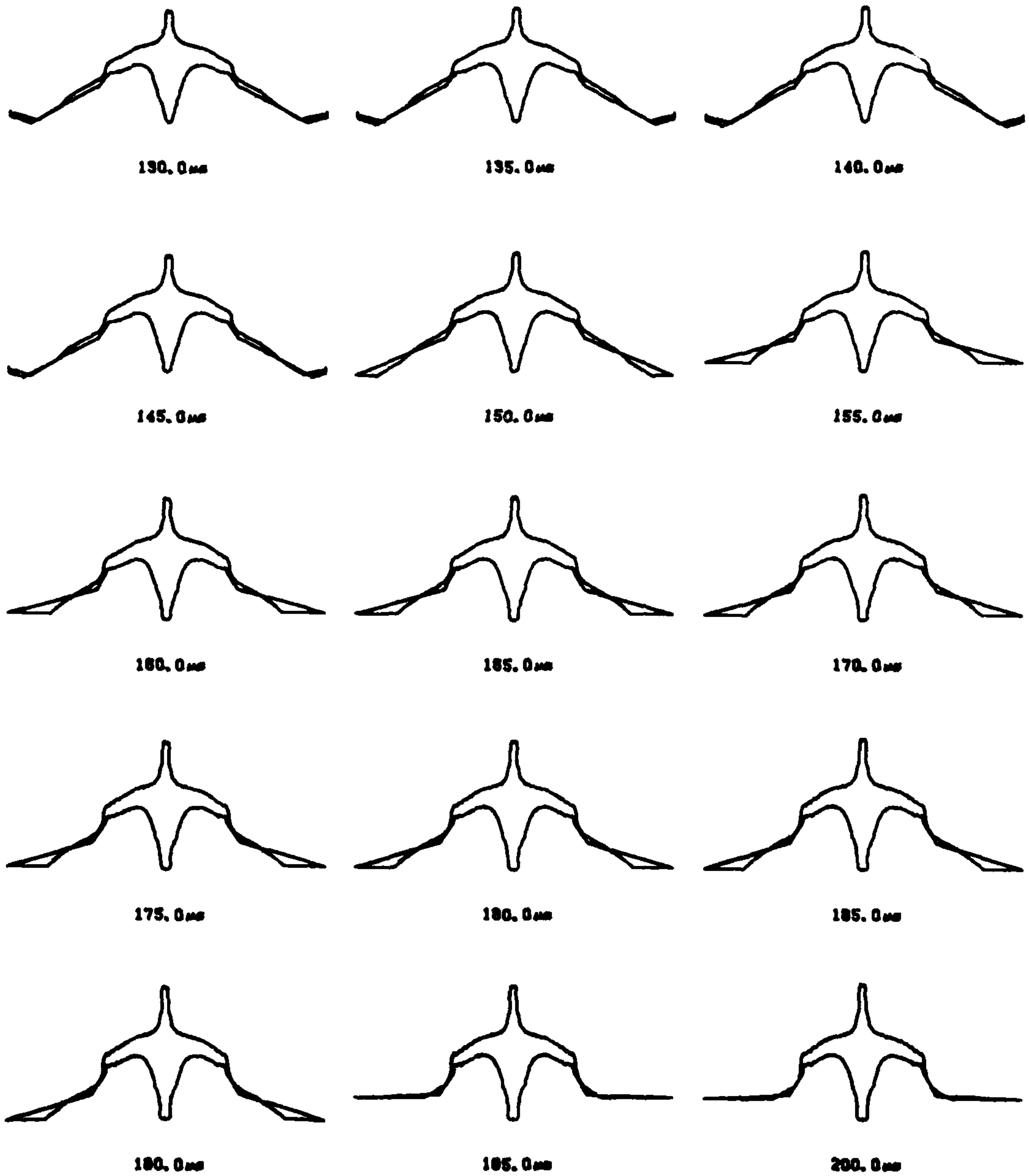


FIGURE 6. (contd.)

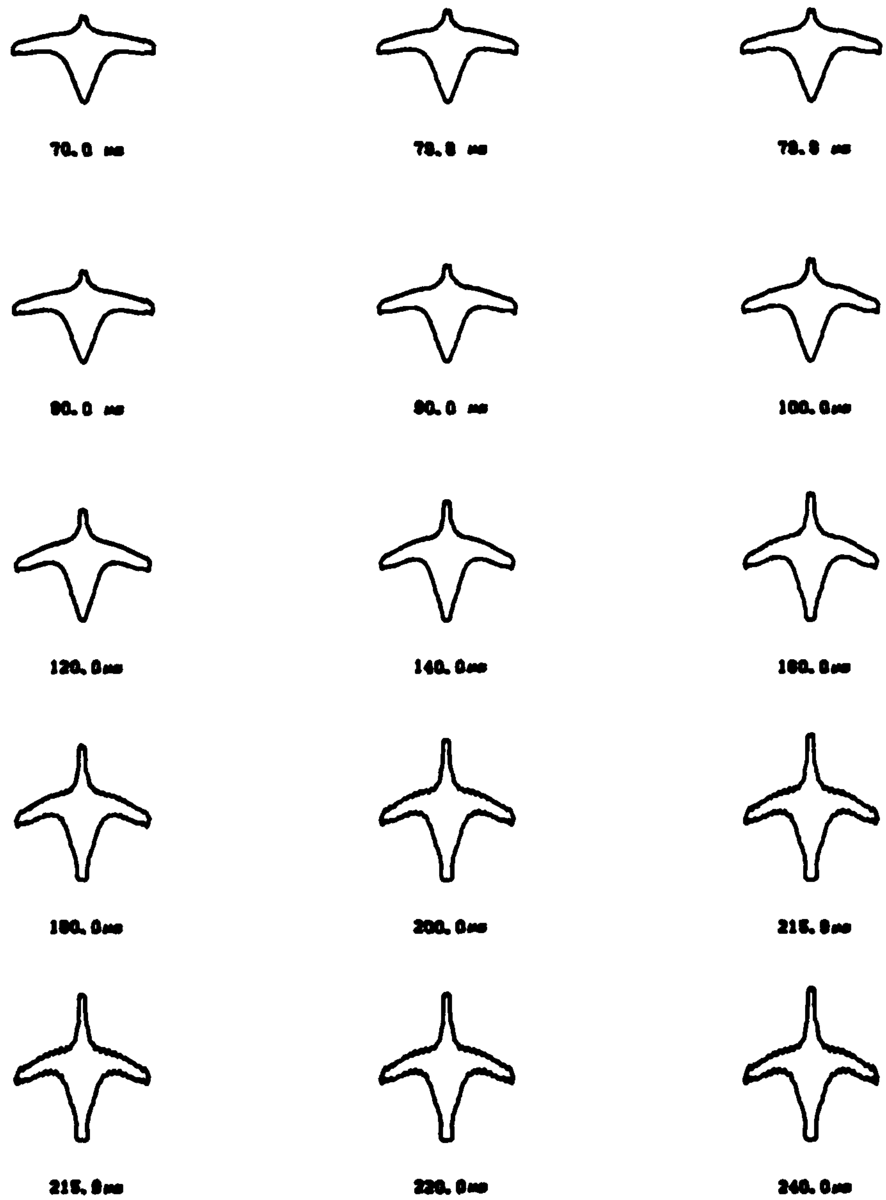


FIGURE 7. Wide-angled Shaped Charge Restart with DEGAS and CLIP.

APPENDIX 1

AN UPDATE RUN TO ADD DEGAS TO THE HELP CODE

```
MAKE6,P1000,T100.
GETSET(SN=DFC4405)
ATTACH(OLDPL,MRLHLP5,SN-DFC4405,ID=DFCDLS)
REQUEST(NEWPL,*PF,SN=DFC4405)
UPDATE(F,L=A1234,N)
REQUEST(LGO,*PF,SN=DFC4405)
FTN(I=COMPILE,LCM=1)
CATALOG(NEWPL,$MRLHLP6 FOR EXPORT$,SN=DFC4405,ID=DFCDLS,RP=100)
CATALOG(LGO,$NEW LGO FOR MRLHLP6$,SN=DFC4405,ID=DFCDLS,RP=100)
*IDENT MOVERR
*DELETE MOVTCR.163,164
C     THIS FIX BY DLS TO PREVENT TRACERS 1 AND NN GETTING STUCK.
C     IT APPEARS THIS WAS INTENDED ORIGINALLY, AT LEAST FOR THE
C     L=NN CASE.  THE PROBLEM BECAME MORE LIKELY TO ARISE WITH
C     THE USE OF THE DEGAS ROUTINE TO ISOLATE PACKAGE ONE.
C
      IF(L.EQ.NN)NT=-1
      IF(TX(N,L+NT).LE.-1000.)GO TO 1505
C     ***NOTE PREVIOUSLY THE PROG SKIPPED TO 1505 IF L WAS 1 OR NN.
C     ***ALSO TX FOR L+1 AND L-1 WERE TESTED, WITHOUT USING NT=-1.
C
*IDENT NOGAS
*DELETE FIT.23
      1 ICSTOP ,PIDY     ,TOPMU     ,RTMU     ,NOGAS    ,NUMEREZ    ,ETH    ,
*DELETE INPUT.35
      1 SIEMIN,     STAB,     TSTOP,     NOGAS
*INSERT INPUT.90
C
C     CALL DEGAS ON RESTART IF NOGAS EQUALS 1
C
      IF (PK(3).LT.0..AND.NOGAS.EQ.1)CALL DEGAS
*ADDFILE
*DECK DEGAS
      SUBROUTINE DEGAS
C     ================
C
C   * * * * * * * * * * * * * * * * * * * * * * * * * *
C   *  THIS SUBROUTINE ISOLATES PACKAGE 1 ON A RESTART RUN, AND      *
C   *  RESTORES THE PROGRAM LOGIC TO ALLOW CALCULATION TO PROCEED.   *
C   *  DEGAS IS CALLED WHEN THE Z-BLOCK VARIABLE NOGAS (Z(11)) IS 1, *
C   *  FOLLOWING A RESTART.  DEGAS IS USED TO REMOVE DETONATION      *
C   *  PRODUCTS WHICH MAY BE ADVERSELY AFFECTING PRESSURE ITERATIONS *
C   *  LONG AFTER THEIR CONTRIBUTION TO THE PROBLEM HAS CEASED.      *
C   *                                                                *
C   *  DEGAS ASSUMES THAT THE PACKAGE YOU WISH TO ISOLATE (USUALLY A *
C   *  WARHEAD LINER OR SIMILAR) IS PACKAGE ONE.                     *
C   *                                                                *
C   *               AUTHOR DAVID L. SMITH, AUGUST 1982.              *
```

```
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
*CALL COMDK
C
      WRITE(6,600)
C
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *      LOOP TO ADJUST THEORETICAL ENERGY FOR REMOVAL OF MATERIALS
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      ESUM=0.
      DO 30 K=2,KMAX
      M=IABS(MFLAG(K))
      IF(M.EQ.1)GOTO 30
      IF(M.LT.100)GOTO 20
      M=M-100
      DO 10 N=2,NMAT
      ESUM=ESUM+XMASS(N,M)*(SIE(N,M)+TKEGM(N,M))
10    CONTINUE
      GO TO 30
20    ESUM=ESUM+AMX(K)*(TKEG(L)+AIX(K))
30    CONTINUE
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *  NOW DEDUCT ESUM FROM ETH, THE THEORETICAL ENERGY OF THE GRID.     *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      ETH=ETH-ESUM
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *                   BEGIN K-LOOP FOR PURE CELLS ONLY                *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      DO 100 K=1,KMAX
      MFK=MFLAG(K)
      IF(MFK.GT.100)GOTO 100
      IF(MFK.EQ.1)GOTO 100
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *                ZERO ALL PURE CELLS EXCEPT PACKAGE 1               *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      U(K)=0.
      V(K)=0.
      AMX(K)=0.
      AIX(K)=0.
      TKEG(K)=0.
      P(K)=0.
      MFLAG(K)=0
      DETIM(K)=0.
      STRSZZ(K)=0.
      STRSRR(K)=0.
      STRSRZ(K)=0.
C     END LOOP FOR PURE CELLS
100   CONTINUE
C
```

```
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C   *                    BEGIN LOOP FOR MIXED CELLS                          *
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
      DO 200 K=1,KMAX
      MFK=MFLAG(K)
      IF(MFK.LE.100)GOTO 200
      M=MFK-100
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C   *      ZERO ALL MATERIALS IN MIXED CELLS EXCEPT PACKAGE 1                *
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
      DO 210 N=2,NMAT
      XMASS(N,M)=0.
      RHO(N,M)=0.
      SIE(N,M)=0.
      TKEGM(N,M)=0.
      US(N,M)=0.
      VS(N,M)=0.
      SAMPY(N,M)=0.
      SGAMC(N,M)=0.
      SAMMY(N,M)=0.
      SAMMP(N,M)=0.
210   CONTINUE
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C   *                 CHECK FOR PRESENCE OF PACKAGE 1                        *
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
      IF(RHO(1,M).GT.0.)GOTO 250
      U(K)=0.
      V(K)=0.
      AMX(K)=0.
      AIX(K)=0.
      TKEG(K)=0.
      P(K)=0.
      STRSZZ(K)=0.
      STRSRR(K)=0.
      STRSRZ(K)=0.
      DETIM(K)=0.
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C   *                   SET FLAG TO RELEASE MIXED CELL                       *
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
      RHO(1,M)=-1.
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C   *                   CONVERT TO PURE VOID CELL                            *
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
      MFLAG(K)=0
C
      GOTO 200
C
250   CONTINUE
```

```
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C     *                 CELL IS KNOWN TO CONTAIN PACKAGE 1              *
C     *                                                                 *
C     *             CELL MUST ALSO NOW CONTAIN VOID PACKAGE             *
C     *              HENCE FLAG VOID AS 1, USING NEW NVOID(2).          *
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C
      RHO(2,M)=1.
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C     *                  CHANGE CELL PROPS TO PACKAGE 1 PROPS           *
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C
      AMX(K)=XMASS(1,M)
      AIX(K)=SIE(1,M)
      U(K)=US(1,M)
      V(K)=VS(1,M)
      TKEG(K)=TKEGM(1,M)
C     END LOOP FOR MIXED CELLS
200   CONTINUE
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C     *                  REMOVE SLIPLINE(S) FROM PROBLEM                *
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C
      DO 300 L=1,NMXCLS
300   THETA(L)=-1.0
C
      DO 310 N=1,NMAT
      MASTRD(N)=0
310   NSLAVD(N)=0
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C     *                          ADJUST TRACERS.                        *
C     *                                                                 *
C     *            (1)   REMOVE TRACERS FROM OLD PACKAGES               *
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C
      DO 400 N=2,NVOID
      DO 400 L=1,NTPMX
      TX(N,L)=0.
      TY(N,L)=0.
400   CONTINUE
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C     *        (2)  PUT TRACERS BACK FOR VOID (REFLECT PACKAGE 1)       *
C     * * * * * * * * * * * * * * * * * * * * * * * * *
C
      NNN=NMP(1)-1
      DO 500 N=1,NNN
      NN2=NNN-N+1
      TX(2,N)=TX(1,NN2)
      TY(2,N)=TY(1,NN2)
500   CONTINUE
      TX(2,NNN+1)=-1000.
      TY(2,NNN+1)=0.
      NMP(2)=NMP(1)
```

```
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *                     ADJUST Z-BLOCK VARIABLES                          *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      NMAT=1
      NOSLIP=1
      NSLD=0
      NTCC=0
      ICLADD=-1
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *                  ADJUST BLANK COMMON VARIABLES                        *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      MOS=0
      NVOID=2
      RMOM=0.
      ZMOM=0.
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *            RESET NOGAS IN Z-BLOCK WHEN DEGAS COMPLETE                 *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      NOGAS=0.
C
C
      WRITE(6,610)
C
      RETURN
C
600   FORMAT(1H1,40H*** SUBROUTINE DEGAS HAS BEEN CALLED ***)
610   FORMAT(1H0,33H*** SUBROUTINE DEGAS COMPLETE ***)
C
      END
```

APPENDIX 2

AN UPDATE RUN TO ADD CLIP TO THE HELP CODE

```
COMPIL,P100,T100.
GETSET(SN=DFC4405)
ATTACH(OLDPL,$NEW MRLHLP8$,SN=DFC4405,ID=DFCDLS)
REQUEST(NEWPL,*PF,SN=DFC4405)
REQUEST(LGO,*PF,SN=DFC4405)
UPDATE(F,N,L=A1234)
FTN(LCM=1,1=COMPILE)
CATALOG(NEWPL,$MRLHLP9$,SN-DFC4405,ID=DFCDLS,RP=900)
CATALOG(LGO,$LGO FOR MRLHLP9$,ID=DFCDLS,SN-DFC4405,RP=900)
*IDENT CLIPIT
*INSERT INPUT.91
C
C     CALL CLIP ON RESTART IF NIMAX GT ZERO
C
      IF(PK(3).LT.0..AND.NIMAX,GT.0)CALL CLIP
C
C
*DELETE FIT.25
      3 IGM     ,SLPNDX     ,SLPNDY      ,DMIN       ,NIMAX      ,DTNA       ,CVIS      ,
*DELETE INPUT.33
      9      NVRTEX,      NIMAX,      PLGOPT,      PLWMIN,      PMIN,      PRCNT,
*ADDFILE
*DECK CLIP
      SUBROUTINE CLIP
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C   *     ROUTINE TO CLIP EDGES OF PACKAGE 1, BY LIMITING IN X-DIRECTION     *
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
*CALL COMDK
      XSTOP=FLOAT(NIMAX)
      KOUNT=0
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C   *                 LOOP TO FIND STRADDLING PAIRS  OF TRACERS               *
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
      DO 10 I=2,NTPMX
      TX1=TX(1,I-1)
      TX2=TX(1,I)
      TY1=TY(1,I-1)
      TY2=TY(1,I)
      IF(TX1.LE.XSTOP.AND.TX2.LE.XSTOP)GOTO 10
      IF(TX1,GE.XSTOP.AND.TX2.GE.XSTOP)GOTO 10
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C   *                    HENCE THIS IS A STRADDLE CASE                        *
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
      NBIGT=1
      IF(TX1.GT.TX2)NBIGT=I-1
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C   *                   INTERPOLATE Y VALUE FOR NEW TRACER                    *
C   *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
```

```
C
      IF(IVARDX.EQ.0.AND.IVARDY.EQ.0)GOTO 11
C   * * * * * * * * * * * * * * * * * * * * * * * * * *
C   *                  CONVERT TO CM UNITS IF NECESSARY.            *
C   * * * * * * * * * * * * * * * * * * * * * * * * * *
C
      TX1=XCTOP(TX1)
      TX2=XCTOP(TX2)
      TY1=YCTOP(TY1)
      TY2=YCTOP(TY2)
      XSTOPC=XCTOP(XSTOP)
      TYNEW=TY1+(XSTOPC-TX1)*(TY2-TY1)/(TX2-TX1)
      TY(1,NBIGT)=YPTOC(TYNEW)
      TX(1,NBIGT)=XSTOP
      GOTO 10
11    TY(1,NBIGT)=TY1+(XSTOP-TX1)*(TY2-TY1)/(TX2-TX1)
      TX(1,NBIGT)=XSTOP
10    CONTINUE
      NNN=NMP(1)
      DO 100 I=1,NNN
      IF(TX(1,I).GY.XSTOP)GOTO 50
      KOUNT=KOUNT+1
      TX(3,KOUNT)-TX(1,I)
      TY(3,KOUNT)=TY(1,I)
50    TX(1,I)=0.
      TY(1,I)=0.
100   CONTINUE
C   * * * * * * * * * * * * * * * * * * * * * * * * * *
C   *                 NOW TRANSFER TRACERS BACK TO PACKAGE 1        *
C   * * * * * * * * * * * * * * * * * * * * * * * * * *
C
      DO 110 I=1,KOUNT
      TX(1,I)=TX(3,I)
      TY(1,I)=TY(3,I)
110   CONTINUE
C
      NMP(1)=KOUNT
C   * * * * * * * * * * * * * * * * * * * * * * * * * *
C   *               TRACERS FOR VOID ... REFLECT PACKAGE 1          *
C   * * * * * * * * * * * * * * * * * * * * * * * * * *
C
      NNN=NMP(1)-1
      DO 490 I=1,NTPMX
      TX(2,I)=0.
490   TY(2,I)=0.
      DO 500 N=1,NNN
      NN2=NNN-N+1
      TX(2,N)=TX(1,NN2)
      TY(2,N)=TY(1,NN2)
500   CONTINUE
      TX(2,NNN+1)=-1000.
      TY(2,NNN+1)=0.
      NMP(2)=NMP(1)
```

```
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *                 ZERO ALL CELLS PAST NIMAX           *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      ESUM=0.
      III=NIMAX+1
      DO 200 J=1,JMAX
      DO 200 I=III,IMAX
      K=(J-1)*IMAX+I+1
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *       ADJUST THEORETICAL ENERGY FOR REMOVAL OF MATERIALS   *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      M-IABS(MFLAG(K))
      IF(M.LT.100)GOTO 230
      M=M-100
      DO 210 N=1,NMAT
      ESUM=ESUM+XMASS(N,M)*(SIE(N,M)+TKEGM(N,M))
210   CONTINUE
      GOTO 200
230   ESUM=ESUM+AMX(K)*(TKEG(K)+AIX(K))
200   CONTINUE
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *          DEDUCT ENERGY FROM THEORETICAL TOTAL, ETH       *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      ETH=ETH-ESUM
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C   *                   ZERO ALL CELLS                    *
C   * * * * * * * * * * * * * * * * * * * * * * * * *
C
      DO 250 J=1,JMAX
      DO 250 I=III,IMAX
      K=(J-1)*IMAX+I+1
      U(K)=0.
      V(K)=0.
      AMX(K)=0.
      AIX(K)=0.
      TKEG(K)=0.
      P(K)=0.
      STRSZZ(K)=0.
      STRSRR(K)=0.
      STRSRZ(K)=0.
      MFK=MFLAG(K)
      MFLAG(K)=0
      IF(MFK.GT.100)GOTO 260
      GO TO 250
260   M=MFK-100
      DO 270 N=1,NMAT
      XMASS(N,M)=0.
      RHO(N,M)=0.
      SIE(N,M)=0.
      TKEGM(N,M)=0.
```

```
      US(N,M)=0.
      VS(N,M)=0.
      SAMPY(N,M)=0.
      SGAMC(N,M)=0.
      SAMMY(N,M)=0.
      SAMMP(N,M)=0.
270   RHO(1,M)=-1.
250   CONTINUE
C    *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C    *                            REDUCE ACTIVE GRID                            *
C    *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
      I1-NIMAX+2
C    *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C    *                              RESET NIMAX                                 *
C    *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
C
      NIMAX=0
      CALL ADDTCR
C
      RETURN
      END
```

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